R E P O R T R E S U M E S

ED 021 072 VT 005 655

AUTOMOTIVE DIESEL MAINTENANCE 1. UNIT I, GENERAL INTRODUCTION TO DIESEL ENGINES.

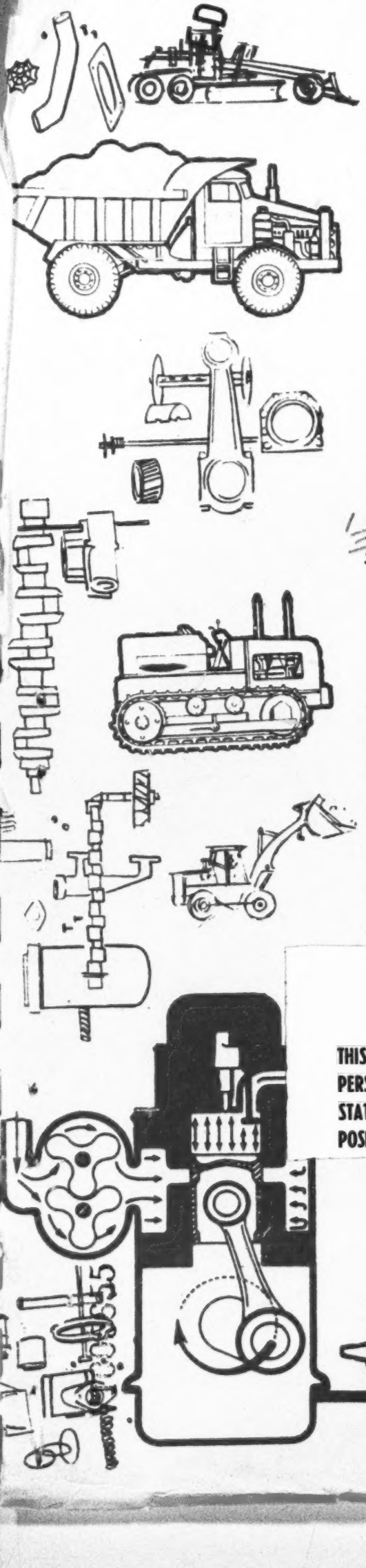
HUMAN ENGINEERING INSTITUTE, CLEVELAND, OHIO
REPORT NUMBER PTAM-1-1 PUB DATE 29 SEP 65
EDRS PRICE MF-$0.25 HC-$1.52 36P.

DESCRIPTORS- *STUDY GUIDES, *TEACHING GUIDES, *TRADE AND INDUSTRIAL EDUCATION, *AUTO MECHANICS (OCCUPATION), *DIESEL ENGINES, ADULT VOCATIONAL EDUCATION, TRANSPARENCIES, PROGRAMED MATERIALS, INDIVIDUAL INSTRUCTION, INSTRUCTIONAL FILMS, PROGRAMED INSTRUCTION, MOTOR VEHICLES, EQUIPMENT MAINTENANCE,

ONE OF A 30-MODULE COURSE DESIGNED TO UPGRADE THE JOB SKILLS AND TECHNICAL KNOWLEDGE OF DIESEL MAINTENANCE MECHANICS, THIS MATERIAL WAS DEVELOPED BY INDUSTRIAL TRAINING AND SUBJECT-MATTER SPECIALISTS AND TESTED IN INDUSTRIAL TRAINING SITUATIONS. THE PURPOSE OF THIS FIRST UNIT IS TO PROVIDE AN INTRODUCTION TO DIESEL ENGINES BY DEVELOPING AN UNDERSTANDING OF THE DIFFERENCES BETWEEN DIESEL AND GASOLINE ENGINES, DIESEL ENGINE COMPONENTS, AND DIESEL OPERATION. THE MODULE CONSISTS OF AN INSTRUCTOR'S GUIDE, TRANSPARENCIES AND A LIST OF SUGGESTED SUPPLEMENTARY MATERIALS FOR 2 HOURS OF GROUP INSTRUCTION, TRAINEE TEXT MATERIAL, AND SELF-INSTRUCTIONAL BRANCH PROGRAMED TRAINING FILM "DIESEL AUTOMOTIVE MAINTENANCE--GENERAL INTRODUCTION" FOR SELF-PACED INDIVIDUAL INSTRUCTION USING AN ELECTRONIC TUTOR. A REPRODUCTION OF THE TRAINING FILM WITH PROGRAM BRANCHING INFORMATION IS INCLUDED SO THAT IT MAY BE DEVELOPED AS PRINTED MATERIAL FOR USE WITHOUT THE ELECTRONIC TUTOR. MODULES IN THIS SERIES ARE AVAILABLE AS VT 005 655 - VT 005 684. MODULES FOR "AUTOMOTIVE DIESEL MAINTENANCE 2" ARE AVAILABLE AS VT 005 685 - VT 005 709. THE 2-YEAR PROGRAM OUTLINE FOR "AUTOMOTIVE DIESEL MAINTENANCE 1 AND 2" IS AVAILABLE AS VT 006 006. THE TEXT MATERIAL, TRANSPARENCIES, PROGRAMED TRAINING FILM, AND THE ELECTRONIC TUTOR MAY BE RENTED (FOR $1.75 PER WEEK) OR PURCHASED FROM THE HUMAN ENGINEERING INSTITUTE, HEADQUARTERS AND DEVELOPMENT CENTER, 2341 CARNEGIE AVENUE, CLEVELAND, OHIO 44115. (HC)

ED 021072

STUDY AND READING MATERIALS



AUTOMOTIVE DIESEL MAINTENANCE

GENERAL INTRODUCTION TO DIESEL EINGINES

UNIT I

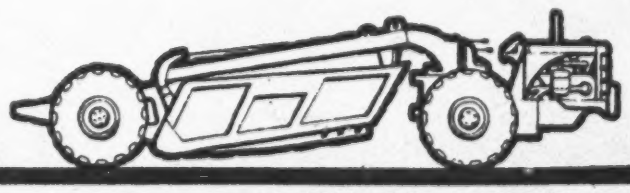
TABLE OF CONTENTS

SECTION A	DIESEL ENGINES VS GASOLINE ENGINES
SECTION B	AIR SUPPLY FOR THE DIESEL
SECTION C	FUEL SUPPLY FOR THE DIESEL
SECTION D	LUBRICATING THE DIESEL
SECTION E	COOLING THE DIESEL
SECTION F	ADVANTAGES OF DIESELS
SECTION G	MECHANICAL FEATURES

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

PTAM 1-1
9/29/65



HUMAN ENGINEERING INSTITUTE

This is the first in a series of text materials about diesel automotive maintenance and the equipment you take care of. It is basically designed to:

1. Better acquaint you with the equipment you maintain.
2. Help you to better understand the reasons why equipment has to be cared for.
3. Assist you in correcting problems that occur when equipment breaks down.
4. Show you the importance of keeping the equipment in peak condition for purposes of economy and efficiency.

Before we start discussing the diesel engine, just a note on class participation: When you have a question, idea, or problem BRING IT UP IN THE CLASS DISCUSSION. Your problem may be the other man's problem too. Active class discussions are healthy, and will make for a better understanding by everyone.

SECTION A -- DIESEL ENGINES VS GASOLINE ENGINES

When the combustion of the fuel takes place inside the engine cylinder, as in a diesel or gasoline engine, the engine is broadly termed an internal combustion engine. Of the many types of internal combustion engines, the gasoline and the oil (diesel) engines are the most common.

Diesel engines use a heavier and less volatile fuel than gasoline engines. This is possible because of the high compression in a diesel engine compressing the air alone until it is so hot that when the oil is sprayed into the cylinder at the height of compression it will ignite without a spark. This eliminates the need for a spark plug, distributor, and all the wiring necessary for the gasoline engine.

Diesels have a compression ratio as high as 21:1, whereas gasoline engines can have only 10:1 at the most. The reason for this is that a mixture of air and fuel enter the cylinder in a gasoline engine. When compression starts,

ignition occurs long before the piston reaches the top due to the high volatile characteristics of the fuel. In a diesel engine, air only is being compressed. The air reaches a temperature of approximately 1000 F at the height of compression. The fuel is then injected in a fine spray through an injector mechanism. The high compression of a diesel allows the engine to get more use out of every gallon of fuel.

Both engines are also classified as to the method of operation, and are known as two-stroke cycle and four-stroke cycle engines. In the two cycle engine, intake and exhaust take place during part of the compression and power strokes. This means there are only two strokes for each complete cycle. The piston fires once for each revolution of the crankshaft. As the piston reaches the downstroke, ports in the cylinder liner are uncovered allowing air to enter the cylinder from the air box, see Figure 1.

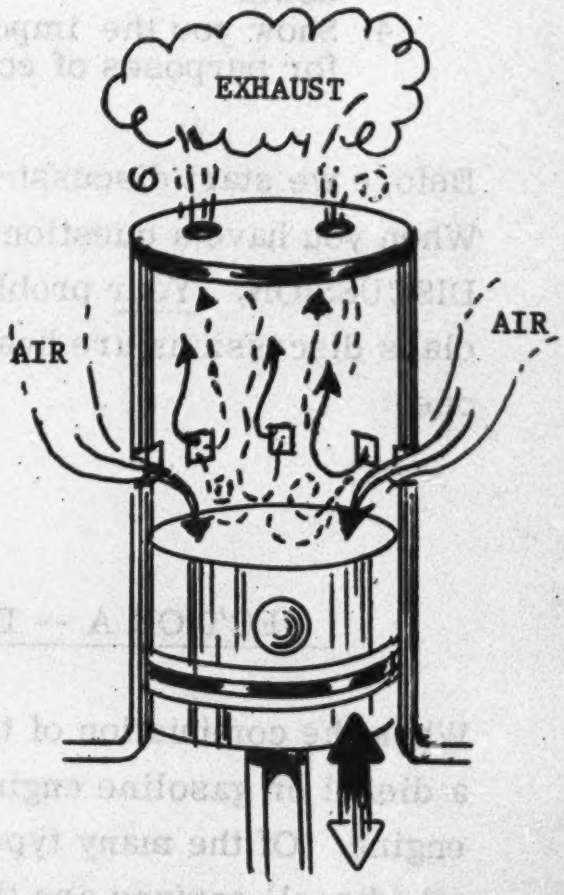


Fig. 1 Two cycle principle.

The blower forces air under pressure into the air box from the outside source. This air serves two purposes for the two cycle engine, (1) it provides fresh clean air for compression and (2) it serves to rid the cylinder of stale gases (scavenging) from the previous explosion. On the GM two cycle the ports are cut at an angle so the air entering the cylinder enters in a swirling motion. This motion rids all corners of the cylinder of stale gases. The stale gases are expelled from the cylinder out the exhaust valves. Some engines are

equipped with two valve heads, some have four.

The four cycle CUMMINS engine requires four strokes to complete a cycle:

1. Air is drawn in through the intake valves at the top of the cylinder when the piston is on the downstroke.
2. Air is compressed on the upstroke of the piston.
3. Fuel is injected at the height of compression resulting in a power stroke.
4. Burned gases are expelled on the exhaust stroke of the piston.

We will get into the four-cycle CUMMINS engine in greater detail later in the year. Since this first part of the year is to be spent on the GM (two-cycle) let's continue with it.

SECTION B -- AIR SUPPLY FOR THE DIESEL

As mentioned before, the four cycle diesel gets its air supply much the same as a gasoline engine does: the air is drawn in as the piston goes down the cylinder. The two cycle, however, cannot use the same principle since exhaust and intake take place at the same time. Therefore, a separate pump is required to supply air to the cylinders. On the GM engine, a blower known as the Roots blower supplies the necessary air. On the inline engine the Roots blower is mounted on the side and driven by the gear train at the rear of the engine. On the V-series the blower is mounted on the top, the method of driving is the same as the inline.

ROOTS BLOWER -- The Roots blower consists of two three-lobed, inter-meshing spiral gears which trap the air and force it to the other side, see Figure 2.

The faster the crankshaft turns, the faster the blower turns, forcing air under pressure (5 to 7 psi) into the air box which surrounds the cylinder liners, see Figure 3.

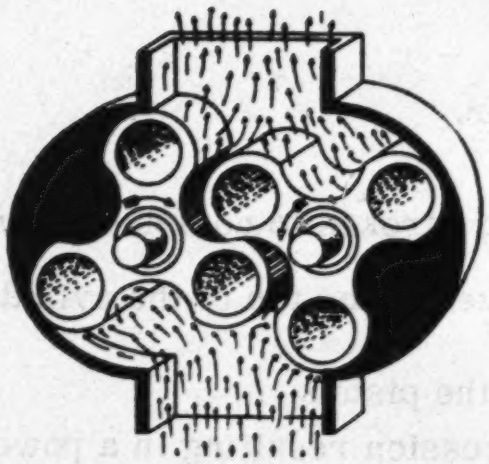


Fig. 2 Roots Blower principle.

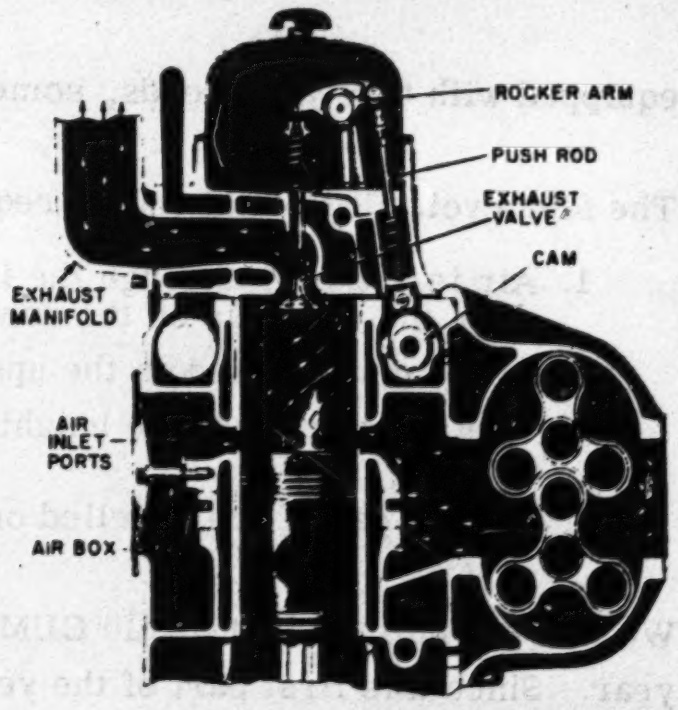


Fig. 3 Operation of the Roots Blower.

SECTION C -- FUEL SUPPLY FOR THE DIESEL

As we said before the fuel injector eliminates the need for a carburetor on the diesel. Each cylinder has its own injector. and with the air tightly compressed and at a high temperature. the injector sprays diesel oil into the cylinder. The oil enters the cylinder at pressures of 20.000 psi in a fine spray or mist. The oil mist begins burning immediately upon contact with the superheated air. More will be said about fuel later. but the characteristic of how fast the fuel will ignite when it enters the piston is called its "Cetane" rating.

The fuel injectors are probably the most critical items in the diesel. Its parts are machined to extremely exacting tolerances. For example. the injector in Figure 4. which is typical of the GM engine. has a tolerance between the plunger and the bushing of 60 millionths of an inch. Every precaution is taken to keep dirt out of the fuel for obvious reasons.

The extreme tolerances are needed because there cannot be any leakage within the plunger and cylinder. The fuel reaches the injector under a pressure of 45 to 65 psi, it is then compressed within the injector and forced through several needle sized holes located on the tip of the injector at pressures up to 20,000 psi.

To vary the engine speed, the amount of fuel sprayed from the injector is changed. Just the right amount of fuel is metered out for the desired speed. This is accomplished through the fuel rack-throttle-governor linkage which will be covered later in greater detail. One point that is important to remember here is that no matter how much the fuel is varied the amount of air taken into the cylinder remains the same.

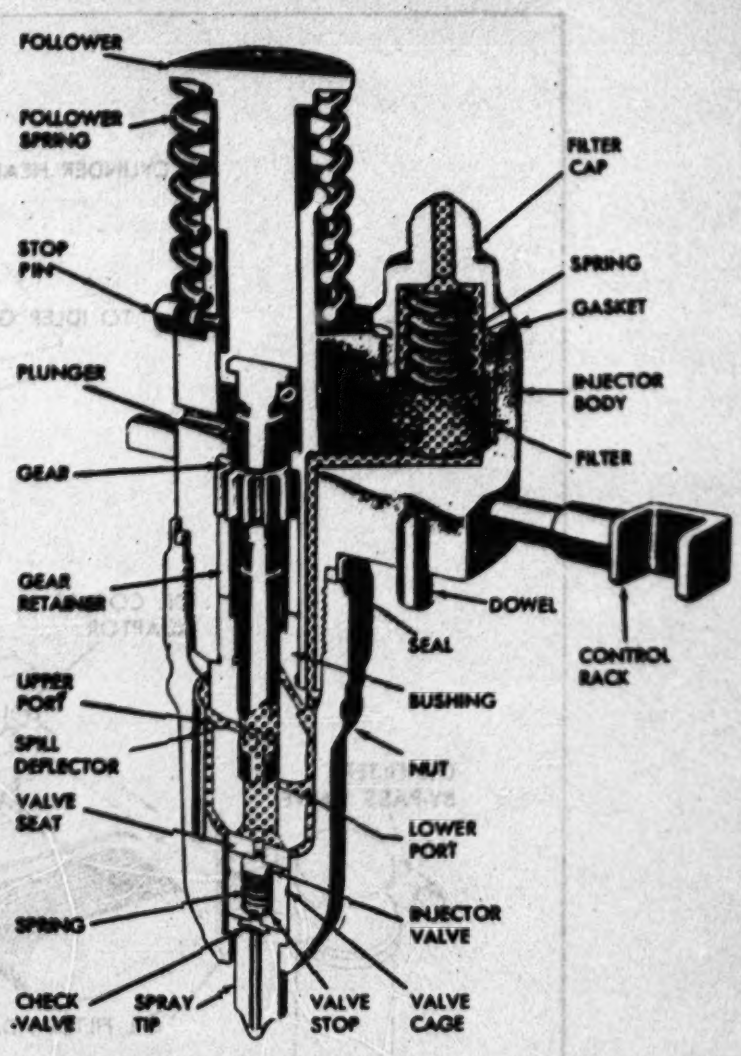


Fig. 4 GM fuel injector.

SECTION D -- LUBRICATING THE DIESEL

All internal combustion engines must have some means of lubrication to reduce the friction of moving parts, and to aid in carrying off heat. All GM engines are lubricated by the combination of pressure feed and splash and spray. At any point in an engine where one part moves over another, a film of oil must be provided to reduce friction, the lubricating oil absorbs and carries away the heat from heavily loaded parts, such as the movement of the camshaft and crankshaft. Figure 5 shows a schematic diagram of the GM V-series type lubricating oil system.

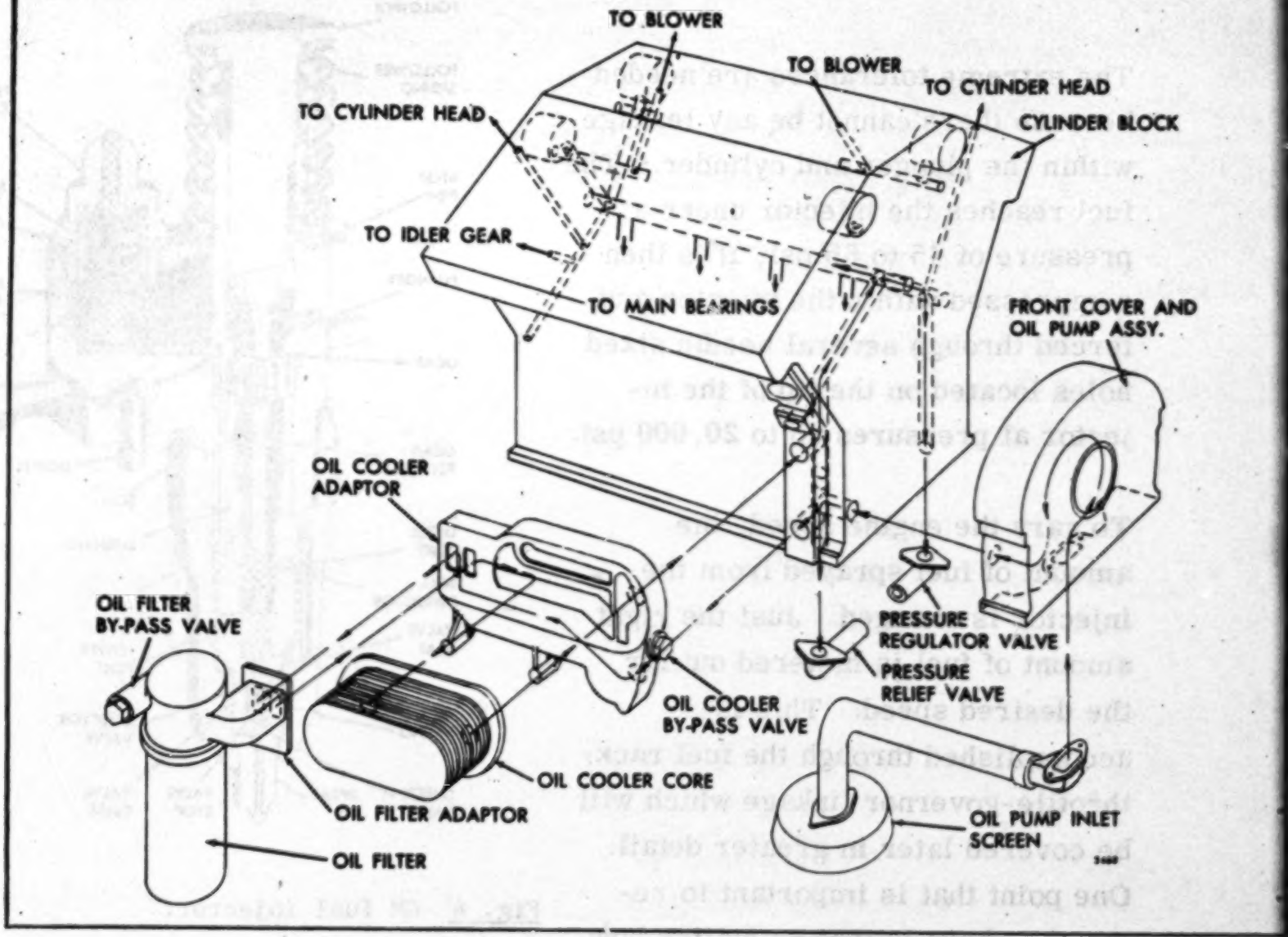


Fig. 5 Typical V-series lubricating system.

SECTION E -- COOLING THE DIESEL

In order to keep the cylinder temperatures within working limits, some means of cooling must be incorporated into the design of the engine. The heat resulting from the burning gases produces extremely high temperatures that would burn up the metals of the cylinder and piston if some means of cooling were not provided. In diesel engines cooling can be done by air or water. The GM system employs a centrifugal type pump to circulate the engine coolant. Each system incorporates thermostats to maintain a normal operating temperature of 160° to 180° F.

The thermostats maintain the operating temperature as follows: at coolant temperatures below approximately 170 F, the thermostat valve remains closed and blocks the flow of coolant through the radiator. As the coolant flowing through the engine block rises in temperature, the thermostat starts to open, allowing coolant to flow through the radiator for additional cooling. The valve will be completely open when the temperature reaches 185 F.

SECTION F -- ADVANTAGES OF DIESELS:

CHEAPER FUEL -- The diesel engine uses fuel costing less than half as much as gasoline and what fuel they do use is used more efficiently.

ECONOMY AT LIGHT LOADS -- Unlike the gasoline engine the diesel at full load is just as economical as it is at idle or partial load.

GREATER SAFETY -- Diesel fuel is much less volatile (active) than gasoline and has much lower burning characteristics. Also, diesel exhaust gases are much less toxic than those from gasoline engines, because there is only a trace of carbon monoxide.

DISADVANTAGES OF DIESELS -- Diesels are more expensive than gasoline engines of comparable horsepower because of their heavy construction. However, the economy and efficiency of operation offsets this disadvantage.

SECTION G -- MECHANICAL FEATURES

Diesel engines are composed of single cylinders put together in various arrangements. We can fasten the cylinders together any way we please, depending on what we are going to use the engine for. The most common is the inline type, with anything from 2 to 8 cylinders. However for space

reasons, the V type engine has become popular for trucks and other mobile equipment; to have 12 to 16 cylinders in a row would require a long truck!

The crankcase and cylinder block are cast in one piece, but a separate liner is inserted in each cylinder. The liner is like a length of tubing which fits in the hole in the block, and provides a replaceable cylinder wall against which the piston rubs. The connecting rods and pistons are similar to the automobile type, although the top surface of the piston will probably have a depression or some other irregular shape instead of being flat. This depends on the type and shape of combustion chamber, more of which will be explained later.

An overhead valve mechanism is used, with the usual push rods and rocker arms. Sometimes the camshaft is located near the top of the engine, and the push rods are very short. In considering the two cycle engine, we should always bear in mind that the camshaft runs at the same speed as the crankshaft. In the four cycle engine the valves are opened only every two revolutions; the camshaft runs half as fast as the crankshaft. In the two cycle engine, the valves must open every revolution; the camshaft runs at crankshaft speed. Camshaft speed is governed by the size of the gears driving the camshaft from the crankshaft.

FLYWHEEL -- When the engine is running, the pressure on the piston is varying constantly, and the reciprocating movement of the piston and rod requires these parts to be brought to a stop and started again twice in each revolution. To provide smoother engine operation, a flywheel is attached to the rear end of the crankshaft. The movement of the flywheel serves to carry the engine during that portion of the piston stroke when the piston is not putting out sufficient power to the crankshaft to carry the load. Also, the pressure of the power strokes to the crankshaft is absorbed by the flywheel.

In this unit we have briefly discussed the mechanics of how a diesel operates, plus a few component parts. We have compared its relation to the gasoline engine and have seen some advantages and disadvantages.

DO NOT FILM THIS PAGE

In the units to follow the four flows of the diesel (i. e. air, fuel, oil, and coolant) will be treated separately in individual units and in much greater detail.

PTAM 1-1D

Diesel Automotive Maintenance - General Introduction

Human Engineering Institute

9/24/65

1

Press A

DO NOT FILM THIS PAGE

2

This is the first of a series of programs that will give you some technical information about diesel engines. You may find that you already know some of the material, but much of it will be new to you. Read carefully and try to answer the questions correctly.

Remember: you want to learn to do more of your job and to do it better.

Press A → 3

1

3

Let's start off by comparing a diesel engine to a gasoline engine; they have many parts in common, such as cylinder blocks, pistons, connecting rods, crankshafts, cams and valves.

They also have some major differences. A diesel engine has no ignition system; the fuel is ignited by contact with highly compressed air. Air, when highly compressed, becomes very hot, and the injection of fuel causes the ignition.

A diesel engine draws air only into its cylinder and compresses this air before any fuel enters the cylinder. As you know, a gasoline engine mixes the air with fuel in a carburetor outside the cylinder.

Press A → 4

1

4

From what you have read, can you complete the following statement? Diesel engines use compression than gasoline engines.

A. less → 5
B. greater → 6
C. I don't know → 5

5

You said diesel engines use less compression than gasoline engines - or that you didn't know. Remember: we said that the diesel engine has no ignition system; the fuel is ignited by contact with highly compressed air. The correct answer is that diesel engines use greater compression than gasoline engines.

Press A → 6

1

6

"Diesel engines use greater compression than gasoline engines" is the correct answer.

In a gasoline engine the amount of compression that can be used is limited - because fuel, as well as air, is being compressed. If the fuel-air mixture is compressed too much, pre-ignition will occur. The efficiency of a gasoline engine is, therefore, limited by the permissible compression ratio (about 7 to one). Diesel compression isn't limited by the chance of pre-ignition - because only air is compressed. Diesel compression ratios are about 16 to 1 - they achieve greater efficiency in the use of fuel.

Press A → 7

1

7

Why can a diesel engine have a higher compression ratio than a gasoline engine?

A. Only air is compressed in the diesel cylinder. → 10
B. The fuel-air mixture in a gasoline engine is too dense to be compressed. → 8
C. The diesel pistons are more sturdily built. → 9

1

8

You said the reason a diesel engine can have a higher compression ratio than a gasoline engine is that the fuel-air mixture in a gasoline engine is too dense to be compressed. Actually this fuel-air mixture would not be too dense to be compressed - but excessive compression would cause pre-ignition. As the air portion of the mixture is highly compressed, the temperature would rise and thus ignite the fuel. This would interfere with the timing of the piston.

Press A → 7

1

PTAM 1-1D

9

You said the reason a diesel engine can have a higher compression ratio than a gasoline engine is that the diesel pistons are more sturdily built. While it is true that the diesel pistons are stronger, this is not the reason for the higher compression ratio. A higher compression ratio in a gasoline engine would result in a pre-ignition and thus interfere with the timing of the piston.

Press A → 7

1

10

"The reason a diesel engine can have a higher compression ratio than a gasoline engine is that only air is compressed in the diesel cylinder" is the correct answer.

We therefore can say a diesel engine is _____ a gasoline engine.

A. less efficient than → 11
B. as efficient as → 12
C. more efficient than → 13

1

11

You said "a diesel engine is less efficient than a gasoline engine." Remember we said a diesel engine has a higher compression ratio than a gasoline engine. Now, the more you can compress the air in a cylinder, the more power you can get from a certain amount of fuel. Since you can compress the air more in a diesel engine than a gasoline engine, you can get more power from less fuel. This makes the diesel engine more efficient than a gasoline engine.

Press A → 10

1

12

You said " a diesel engine is as efficient as a gasoline engine." Remember we said a diesel engine has a higher compression ratio than a gasoline engine. Now, the more you can compress the air in a cylinder, the more power you can get from a certain amount of fuel. Since you can compress the air more in a diesel engine than a gasoline engine, you can get more power from less fuel. This makes the diesel engine more efficient than a gasoline engine.

Press A → 10

1

13

" A diesel engine is more efficient than a gasoline engine" is the correct answer.

Diesel engines use heavier liquid fuels than gasoline engines. These heavier fuels are slower to change to a vapor than gasoline - and they're cheaper, too. Gasoline engines must use a fuel that evaporates at a low temperature, to form a uniform mixture with the air flowing through the carburetor.

Diesel engines use fuel pumps and injection nozzles to inject the fuel into the cylinder in a fine spray for combustion. Gasoline engines mix the fuel and air in a carburetor before the mixture flows into the cylinder.

Press A → 14

1

14

One other way in which diesel engines differ from gasoline engines is in their weight. Because the diesel engines work with higher compression ratios the engines must be _____ than gasoline engines of the same size.

A. lighter → 15
B. heavier → 16
C. I don't know → 15

1

15

You said diesel engines " must be lighter than" gasoline engines of the same size, or that you didn't know the answer.

Stop and think for a minute. Remember we said they work with higher compression ratio than the gasoline engines. There is therefore more power being exerted per amount of fuel used. Because there is more power being exerted the engine parts must be stronger. This means that diesel engines must be heavier than gasoline engines of the same size.

Press A → 14

1

16

"Diesel engines must be heavier than gasoline engines of the same size" is the correct answer.

From what we have covered so far, you should be able to see several advantages of a diesel engine.

Which of the following is an advantage of a diesel engine over a gasoline engine?

A. Although its fuel is expensive, it uses a very small amount. → 17
B. Although it uses a lot of fuel, the fuel is cheap. → 18
C. It uses a small amount of cheap fuel. → 19

1

PTAM 1-1D

17

You said one of the advantages of a diesel engine is that "although its fuel is expensive, it uses a very small amount."

Diesel engines use a very heavy fuel which does not have to be refined to the extent that fuel for gasoline engines must be refined. This makes the cost of the fuel cheaper for diesel engines than for gasoline engines.

Press A → 16

1

NOT FILM THIS PAGE

You said one of the advantages of a diesel engine is that "although it uses a lot of fuel, the fuel is cheap."

Remember we said that the diesel engines have a high compression ratio. This means more power from less fuel. The diesel engine, therefore, uses less fuel than a gasoline engine.

Press A → 16

1

19

"One of the advantages of a diesel engine is that it uses a small amount of cheap fuel" is the correct answer.

Which of the following is an advantage of a diesel engine over a gasoline engine because of the type of fuel that is used.

A. Greater safety → 22
B. Less weight → 20
C. There is no advantage → 21

1

20

You said that an advantage of a diesel engine over a gasoline engine is "less weight" because of the type of fuel used.

Remember we said that a diesel engine uses heavier fuel and because of its higher compression ratios, the engines are heavier than gasoline engines.

Because the type of fuel used is heavier and evaporates more slowly than fuel for gasoline engines, the diesel fuel is less volatile (active). This means greater safety.

Press A → 19

1

21

You said there is "no advantage" of a diesel engine over a gasoline engine because of the type of fuel that is used.

Think for a moment. Remember we said a diesel engine was a heavier fuel. This fuel evaporates much more slowly than fuel for gasoline engines and is less volatile (active). This means greater safety.

Press A → 19

1

22

"Diesel fuel means greater safety" is the correct answer. The reason is that the fuel is less volatile (active).

Some of the other advantages of diesel engines are: economy at light loads and in small sizes.

A diesel engine is efficient when fully loaded - and also when partly loaded. When running at half load, the diesel engine consumes only about 10 percent more fuel - per unit of power produced - than it does at full load. The efficiency of other engines drops off greatly when the load is reduced.

Press A → 23

1

23

From what we have read about diesel engines, which of the following would you say is a major DISadvantage of a diesel engine as compared to a gasoline engine?

A. It is more complicated and thus more expensive to manufacture. → 24
B. It is not as economical to operate. → 25
C. It is heavier and more expensive to manufacture. → 26

1

24

You said one of the major disadvantages of a diesel engine as compared to a gasoline engine is that "it is more complicated and thus more expensive to manufacture."

A diesel engine is not more complicated than a gasoline engine. It may seem more complicated, but you will soon find it as easy to understand as a gasoline engine.

One of the major disadvantages of a diesel engine as compared to a gasoline engine is that it is heavier and thus more expensive to manufacture.

Press A → 23

1

PTAM 1-1D

25

You said one of the major disadvantages of a diesel engine as compared to a gasoline engine is that "it is not as economical to operate."

Remember we mentioned that diesel fuel is cheaper than the fuel for gasoline engines. Diesel engines also have a higher compression ratio which means more power from less fuel. Diesel engines, therefore, are more economical to operate than gasoline engines.

One of the major disadvantages of a diesel engine as compared to a gasoline engine is that it is heavier and thus more expensive to manufacture.

Press A → 23

1

26

NOT FILM THIS PAGE

"Diesel engines are heavier and are more expensive to manufacture" is the correct answer.

If you answered all the questions correctly, we will now go on to new material.

Press A → 28.
(X C) → 27

1

27

You answered one or more questions incorrectly. Let's review the material we have just covered. Read carefully and try to answer all the questions correctly.

Press A → 3

1

28

TWO-CYCLE AND FOUR-CYCLE DIESEL ENGINES

There is a major difference between the construction and operation of diesel engines in regard to the cycles, or piston strokes, necessary to produce power. Some use a four stroke cycle and others, a two stroke cycle. First we will discuss the four stroke cycle.

Press A → 28½

2

28½

In the four stroke cycle engine the first phase of operation occurs when the piston goes down to permit air to come into the cylinder through the intake valve. This is called a suction stroke.

The next step would be to _____ the air.

A. inject fuel into → 29
B. compress → 31
C. agitate → 30

2

29

You said the next step would be to "inject fuel into the air." Stop and think for a moment. How does a diesel engine operate? Remember we discussed in the first part of this program that a diesel does not use an ignition system. The heat for combustion comes from compressing the air. Therefore after the suction stroke, the next step would be to compress the air.

Press A → 28½

2

30

You said the next step would be to "agitate the air." Stop and think for a moment. What would be the advantage of agitating the air? Remember, in a diesel engine the heat for combustion comes from compressing the air, not agitating it. Therefore, the next step after the suction stroke would be to compress the air.

Press A → 28½

2

31

"After the suction stroke, the next step would be to compress the air" is the correct answer.

At this point when the air has been compressed, the piston has completed _____ cycle(s).

A. one → 32
B. two → 34
C. one half of a → 33

2

PTAM 1-1D

32

You said that when the air has been compressed the piston has completed "one cycle". Let's look at the action again. First the piston has moved down to suck air into the cylinder. This counts as one cycle. The piston then goes up to compress the air. This also counts as one cycle. Therefore, you can see that when the air has been compressed, the piston has made two strokes - one up and one down. It has completed two cycles.

Press A → J1

2

33

You said that when the air has been compressed the piston has completed "one-half of a cycle."

Let's look at the action again. First the piston moves down to suck air into the cylinder. The piston has completed one stroke and one cycle. The piston then moves up to compress the air. The piston now has completed another stroke and another cycle. Therefore, two cycles have been completed.

Press A → J1

2

34

"When the air has been compressed, the piston has completed two cycles" is the correct answer.

Now, when the air has been compressed, fuel is injected into the cylinder by means of a fine spray. The resulting combustion then forces the piston back down. This power stroke is the one that provides the power to turn the crankshaft. This stroke also counts as the third cycle.

Just before this stroke is completed, the exhaust valves open. When the piston has completed its downward stroke and starts up again, it forces the burnt gases out through the exhaust valves. This upward stroke of the piston counts as the fourth cycle.

Press A → J5

2

35

In a four cycle diesel engine the cylinder makes two downward strokes. What are the purposes of these strokes?

A. Compression and power → J6
B. Exhaust and power → J7
C. Air induction and power → J8

2

36

You said the purposes of the downward piston strokes in a four cycle diesel are compression and power.

You are partly right. The purpose of one of the downward piston strokes is power to turn the crankshaft. A downward piston stroke, however, provides more room in the cylinder and thus allows air to come into the cylinder. Compression takes place on an upward stroke. The correct answer was: air induction and power.

Press A → J8

2

37

You said the purposes of the downward piston strokes in a four cycle diesel are exhaust and power.

You are partly right. The purpose of one of the downward piston strokes is power to turn the crankshaft. A downward piston stroke, however, provides more room in the cylinder. This would not encourage an exhaust action. Burnt gases are exhaused on an upward stroke. The correct answer was: air induction and power.

Press A → J8

2

38

"The purpose of the two downward strokes in a four cycle diesel engine is air induction and power" is the correct answer.

What is the correct order of cycles in a four cycle diesel engine?

A. Air induction, compression, power, exhaust. → 41
B. Compression, exhaust, power, air induction. → J5
C. Power, compression, exhaust, air induction. → 40

2

39

You said the correct order of cycles in a four cycle diesel engine is: compression, exhaust, power, air induction.

Let's look at your answer. Compression and exhaust are accomplished by upward strokes of the piston. If the air is compressed, what would you exhaust?

We hope these hints have clarified the order of the cycles for you. The CORRECT ORDER is:

1. Air induction (piston down).
2. Compression (piston up).
3. Power (piston down).
4. Exhaust (piston up).

Press A → 41

2

PTAM 1-1D

40

You said the correct order of cycles in a four cycle diesel engine is: power, compression, exhaust, air induction.

Let's look at your answer. What causes the power? Compression and exhaustion are both upward strokes; how can they follow each other?

We hope these hints have clarified the order of the cycles for you. The CORRECT ORDER is:

1. Air induction (piston down).
2. Compression (piston up).
3. Power (piston down).
4. Exhaust (piston up).

Press A → 41

2

41

"The correct order of cycles in a four cycle diesel engine is (1) air induction (piston down), (2) compression (piston up), (3) power (piston down), (4) exhaust (piston up)" is the correct answer.

As the piston moves down after the explosion (power stroke), inlet ports are uncovered which surround the cylinder liner. Simultaneously, the exhaust valves are opened. Air under pressure from the air box moves into the cylinder and forces the burnt gases out through the exhaust valves.

Press A → 42

2

42

As the air enters the cylinder, a swirling action is created to rid the cylinder of all burnt gases. When all gases are expelled, the cylinder is full of fresh clean air. As the piston moves up, the inlet ports are closed as well as the exhaust valves, and compression begins. This completes the four events in two cycles.

Press A → 43

2

43

In a two cycle diesel engine, air induction and exhaust take place on _____ strokes of the piston.

A. both downward and upward → 44
B. the upward → 45
C. the downward → 46

2

44

You said that in a two cycle diesel engine air induction and exhaust take place on "both the downward and upward strokes" of the piston. Let's go back and read about the two cycle diesel engine again.

Read carefully.

Press A → 41

2

45

You said that in a two cycle diesel engine air induction and exhaust take place "on the upward stroke of the piston."

Perhaps you have upward and downward mixed up. Remember - on the upward stroke of the piston the air is compressed. Air induction has been completed after the piston passes a certain point. In a two cycle diesel, when the piston moves down it uncoveres the air inlet ports.

Press A → 46

2

46

"In a two cycle diesel engine air induction and exhaust take place on the downward stroke of the piston" is the correct answer.

The two cycle diesel differs from a four cycle diesel in that it does not have separate piston strokes for:

A. air induction and exhaust. → 45
B. power and compression. → 47
C. exhaust and compression. → 48

2

47

You said a two cycle diesel differs from a four cycle diesel in that it "does not have separate piston strokes for power and compression."

Power and compression, however, make up the two strokes in a two cycle diesel engine. The compression stroke is upward and the power stroke is downward.

The CORRECT answer is that the two cycle diesel engine does not have separate piston strokes for air induction and exhaust. These are taken care of on the downward stroke of the piston.

Press A → 45

2

PTAM 1-1D

48

You said a two cycle diesel differs from a four cycle diesel in that it "does not have separate piston strokes for exhaust and compression."

Let's look at the operation of a two cycle diesel again. Remember it has two strokes - the compression stroke (upward) and the power stroke (downward).

The correct answer is that the two cycle diesel engine does not have separate piston strokes for air induction and exhaust. These are taken care of on the downward stroke of the piston.

Press A → 45

2

45

"The two cycle diesel differs from a four cycle diesel in that it does not have separate piston strokes for air induction and exhaust" is the correct answer.

Now, if you answered all the questions correctly, you will go on to new material.

Press A → 51

(x C) → 50

2

50

You answered one or more questions incorrectly. Let's review the material on four and two cycle diesel engines again. Read carefully and try to answer all the questions correctly.

Press A → 28

2

51

Diesel engines are composed of single cylinders put together in various arrangements. They can be assembled in various arrangements - depending on the use of the engine. Where space is a problem and much horsepower is required, the Vee type engine is generally used.

In diesels the crankcase and cylinder block are cast in one piece, but a separate liner is inserted in each cylinder. It provides a replaceable cylinder wall against which the piston rubs.

Press A — 51 1/2

3

51 1/2

As a maintenance man, what would you most frequently be replacing?

A. Cylinder block → 52
B. Crankcase → 53
C. Cylinder lining → 54

3

52

You said as a maintenance man you would most frequently be replacing "the cylinder block". Remember we said the cylinder block and crankcase were cast in one piece. If you were replacing the cylinder block you would also be replacing the crankcase - which was choice "C" in the question.

The correct answer is that you would most frequently be replacing the cylinder lining. This is made so that it can be replaced when worn beyond the allowable limits.

Press A → 54

3

53

You said as a maintenance man you would most frequently be replacing "the crankcase". Remember we said the crankcase and the cylinder block were cast in one piece. If you were replacing the crankcase, you would also be replacing the cylinder block which was choice "A" in the question.

The correct answer is that you would most frequently be replacing the cylinder lining. This is made so that it can be replaced when worn beyond the allowable limits.

Press A → 54

3

54

"As a maintenance man you would most frequently be replacing the cylinder lining" is the correct answer.

An overhead valve mechanism is used in diesels with the usual push rods and rocker arms. In considering the two cycle engine, keep in mind that the camshaft runs at the same speed as the crankshaft. In the four cycle engine the valves are opened only every two revolutions, so the camshaft runs half as fast as the crankshaft.

Press A → 55

3

PTAM 1-1D

55

The cam shaft on a two cycle engine turns _____ the crankshaft.

A. at the same speed as → 58
B. faster than → 56
C. slower than → 57

3

56

You said the camshaft on a two cycle engine turns "faster than the crankshaft." No; you are wrong. The gear train connecting the camshaft(s) to the crankshaft are a one to one ratio ---they turn at the same speed.

Press A → 58

3

57

You said the camshaft on a two cycle engine runs at "a slower speed than the crankshaft." You appear to have the two cycle engine confused with the four cycle engine. In the four cycle engine the valves are opened only every two revolutions, so the camshaft runs half as fast as the crankshaft.

On a two cycle engine the camshaft runs at the same speed as the crankshaft.

Press A → 58

3

58

"On a two cycle engine the camshaft runs at the same speed as the crankshaft" is the correct answer.

Getting air into a four cycle diesel engine is the same as getting the fuel-air mixture into an automobile engine. The overhead valve opens, the piston goes down, and the outside atmospheric pressure forces the air in. The only thing we have to remember is that it is air only; no fuel is mixed with it when it enters the cylinder.

In a two cycle engine we do not have an air induction cycle, as in the four cycle, and since there is such a short time to get the air in the cylinder a blower is required. The most common type of blower is a Roots blower.

Press A → 59

3

59

A Roots blower is a casing with two rotating parts or rotors. Each rotor has three lobes that fit together like gear teeth as the rotors are driven around. They are driven from the engine crankshaft. Air is forced by the blower into the air box surrounding the lower part of the cylinders. This creates a pressure so that when the piston is down the air inlet valves open and fresh air rushes into the cylinder. This fresh air also helps push out the exhaust gases. The flow of air is always in one direction.

In some arrangements the air is blown directly into the cylinder. It swirls through, sweeping out the burned gases. As the piston rises it closes off the air inlets and compresses the fresh, clean air remaining.

Press A → 60

3

60

We will find a Roots blower in _____ cycle diesel engines.

A. four → 61
B. two → 63
C. two and four → 62

3

61

You said you would find a Roots blower "in a four cycle diesel engine." You are incorrect. Remember a four cycle engine has a separate cycle for air induction and exhaust. A two cycle engine must handle air induction and exhaust at the time the piston is at the bottom of the cylinder. Because of the time element, a Roots blower is used.

Press A → 63

3

62

You said you would find a Roots blower in "both a two and four cycle diesel engine." You are incorrect. Remember a four cycle engine has a separate cycle for air induction and exhaust, and thus has no need for a blower. A two cycle engine must handle air induction and exhaust at the time the piston is at the bottom of the cylinder. Because of the time element, a Roots blower is used to handle air induction and speed the exhaust.

Press A → 63

3

PTAM 1-1D

63

"You will find a Roots blower in a two cycle diesel engine" is the correct answer.

A Roots blower is a casing with (1) _____ rotating parts and each has (2)_____ lobes that fit together like gear teeth.

A. (1) three, (2) three → 63 1/2
B. (1) two, (2) four → 63 1/2
C. (1) two, (3) three → 64

3

63 1/2

DO NOT FILM THIS PAGE

No, you are incorrect. A Roots blower is a casing with two rotating parts, and each has three lobes that fit together like gear teeth.

Press A → 64

3

64

"Two rotating parts and three lobes" is the correct answer.

The primary job of the fuel system of a diesel engine is to see that the right amount of fuel is injected into a cylinder at the right time. This makes the injector the most important part of the system.

The fuel system also has a fuel tank and a pump to carry the fuel to the injectors. There is also a return fuel line to carry the unused fuel back to the tank. Dirt is the major enemy of a diesel fuel system - so we have a filter between the fuel tank and the fuel pump, and another filter to clean the oil just before it reaches the injector.

Press A → 65

3

65

What is the most important part of the fuel system of a diesel engine?

A. The injector. → 64
B. The filters. → 66
C. The fuel pump. → 67

3

66

You said "the filters" were the most important part of the fuel system of a diesel engine. The filters are very important but the most important part of the system is the injector. The injector must inject the proper amount of fuel into the cylinder at the proper time.

Press A → 64

3

67

You said "the fuel pump" was the most important part of the fuel system of a diesel engine. The fuel pump is important but the injector is the most important part. The injector must see that the proper amount of fuel is injected into the cylinder at the proper time.

Press A → 64

3

68

"The injector" is the correct answer.

What is the major enemy of a diesel fuel system?

A. Water → 65
B. Oil → 70
C. Dirt → 71

3

65

You said "water" was the major enemy of the diesel fuel system. You are incorrect.

DIRT is the major enemy, remember they have two filters in the fuel system to eliminate dirt.

Press A → 71

3

PTAM 1-1D

70

You said "oil" was the major enemy of the fuel system. You are incorrect. DIRT is the major enemy, remember they have two filters in the fuel system to eliminate dirt.

Press A → 71

3

DO NOT FILM THIS PAGE

71

"DIRT is the major enemy of a diesel fuel system" is the correct answer.

The high speed diesel engines we have today are just as particular about their fuel as any gasoline engine. Poor fuel can mean hard starting, incomplete combustion, smoky exhaust, and knocking.

Fuel is measured by cetane numbers. Cetane numbers indicate the ability of certain fuels to ignite faster than others. The higher the cetane number is, the faster the fuel will ignite after injection. The large, slow diesel can use 30 cetane fuel. The high speed diesels must use at least 45 cetane, with some requiring as high as 60.

Press A → 72

3

72

Diesel fuel has an advantage over gasoline from the safety standpoint. It does not give off vapor as readily, so it doesn't usually form an explosive air-fuel mixture when spilled (or in case of a leak). This is important for uses where the fire hazard is great.

What does the cetane number indicate in diesel fuel?

A. Density → 73
B. Vapor quality → 73
C. Ignition quality → 74

3

73

You are incorrect. The cetane number of diesel fuel indicates the ignition quality of the fuel.

"Ignition quality" is the correct answer.

Press A → 74

3

74

The higher the cetane number the _____ will be the ignition quality of the fuel.

A. poorer → 74½
B. better → 75

3

74½

Higher cetane numbers indicate better ignition quality of the fuel.

Press A → 74

3

75

Diesel fuel has an advantage over gasoline from a(n)_____ standpoint.

A. ignition → 76
B. power → 77
C. safety → 78

3

76

You said "from an ignition standpoint" diesel fuel has an advantage over gasoline.

Because diesel fuel does not evaporate as readily as gasoline, it actually has a poorer ignition.

Diesel fuel has an advantage from a SAFETY standpoint.

Press A. → 78

3

PTAM 1-1D

77

You said diesel fuel has an advantage over gasoline "from a power standpoint."

You seem to be confusing the engines with their fuels. A diesel engine is designed to produce more power. The fuel used is not of importance from the standpoint of power produced.

Diesel fuel has an advantage from a SAFETY standpoint.

Press A → 78

3

78

"Diesel fuel has an advantage over gasoline from a safety standpoint" is the correct answer.

There is no ignition system, as such, in a diesel; the oil is ignited because air has been compressed to the point where it is hot enough to start the oil burning.

For the fuel to burn properly it must be mixed thoroughly with the compressed air. We atomize the fuel as much as possible with the injector. Most injectors have six pin holes on the tip.

Press A → 75

3

75

What do we do to diesel fuel so it will mix properly with the air in the cylinder?

A. Heat it. → 80
B. Atomize it. → 81
C. Cool it. → 80

3

80

You are incorrect if you said we heat or cool the fuel so it will mix properly with the air in the cylinder. The correct answer is ATOMIZE the oil.

Press A → 81

3

81

O. K. We atomize the oil so it will mix properly with the air in the cylinder.

We are also concerned with how fast the oil burns. We want a little to start burning as soon as possible and have this ignite the rest. We don't want a lot of fuel burning in one place all at once. This gives sudden high pressures and a tendency to knock, and makes a stronger, heavier engine necessary. The fuel and the combustion system can control these problems.

The combustion system really means the shape of the combustion chamber.

Press A → 82

3

82

Some engines use a pre-combustion chamber. An auxiliary chamber is located at one side of the top of the cylinder. The piston almost touches the cylinder head at the top of its stroke. The air is pushed into the small chamber at high speed so it is whirling around at the moment the oil is injected. The turbulence mixes the oil and air and the combustion expands into the main cylinder.

Other engines us an energy cell. The combustion chamber is shaped like a figure 8. Turbulence is caused by the combustion expansion in two chambers.

Press A → 83

3

83

What do we mean when we talk about the combustion system of a diesel engine?

A. The fuel pump and the injectors → 84
B. The injectors and Root blowers. → 84
C. The shape of the combustion chamber. → 85

3

84

No, - you are incorrect. When we talk about the combustion system of a diesel we are referring to the shape of the combustion chamber. Remember: this determines how the fuel will burn.

Press A → 85

3

PTAM 1-1D

85

In an energy cell type combustion system we have__ _____.

A. an auxiliary chamber where the fuel is ignited → 87
B. a figure 8 type combustion chamber → 84
C. a circular chamber with grooved sides → 86

3

86

No, you are confused. A circular chamber with grooved sides would be of little value to aid combustion. An energy cell type combustion system has a figure 8 type combustion chamber.

Press A → 88

3

87

No. You are confusing the energy cell type combustion system with a pre-combustion system. An energy cell type system has a figure 8 type combustion chamber.

Press A → 84

3

88

"A figure 8 type combustion chamber" is the correct answer.

What are we concerned with in a combustion system of a diesel?

A. That the fuel and air are properly mixed. → 91
B. That the fuel burns all at once in one place in a big explosion. → 89
C. That the air stays relatively calm. → 90

3

89

No, you are incorrect. In a diesel we do NOT want the fuel to burn all at once in one place. This could cause sudden high pressures and a tendency to knock. It would also make a stronger, heavier engine necessary.

In the combustion system we are concerned that the fuel and air are properly mixed.

Press A → 91

3

90

No, you are incorrect. In a diesel we do NOT want the air to stay calm. The more turbulent we can make the air, the better. We want the air and fuel to be properly mixed.

Press A → 91

3

91

"That the fuel and air are properly mixed" is the correct answer.

In a diesel we do not worry about the mixture ratio of fuel to air. It is not necessary to have just 15 parts of air to one part of fuel. Usually we have more air. We completely fill the cylinder with air on each stroke, whether we are injecting a small amount of fuel for idling or a full charge for maximum power. Because we always have more than enough air in the cylinder we get better fuel economy at part load than we do in a carburetor engine. The efficiency of a diesel engine does not drop off when it is running at less than full power.

Press A → 92

3

92

In a diesel engine we control the amount of speed by _____.

A. the amount of air allowed in the cylinder → 93
B. the force of the piston on the upward stroke → 94
C. the amount of fuel injected into the cylinder → 95

3

PTAM 1-1 D

53

No. You are incorrect. The amount of speed in a diesel is NOT controlled by the amount of air allowed in the cylinder. We have no way of controlling this. We control the speed by the amount of fuel injected into the cylinder.

Press A → 55

3

54

No, you are incorrect. We do NOT control the speed in a diesel by the force of the piston on the upward stroke. This force always remains the same. We control the speed by the amount of fuel injected into the cylinder.

Press A → 55

3

55

"The amount of fuel injected into the cylinder" is the correct answer.

Compared to a gasoline engine a diesel engine on part load is _____.

A. more efficient → 57
B. less efficient → 56
C. as efficient as the gasoline engine → 56

3

56

No. You are incorrect. One of the advantages of a diesel engine is that it is more efficient than a gasoline engine on part load.

Press A → 58

3

57

"Compared to a gasoline engine a diesel engine on part load is more efficient" is the correct answer.

Press A → 58

3

58

Congratulations. You have answered all the questions correctly and have finished this program on diesel engines.

Press Rewind

(X c) → 55

3

59

You answered one or more questions incorrectly. Let's review the material again. Try to answer all the questions correctly this time.

Read carefully.

Press A → 51

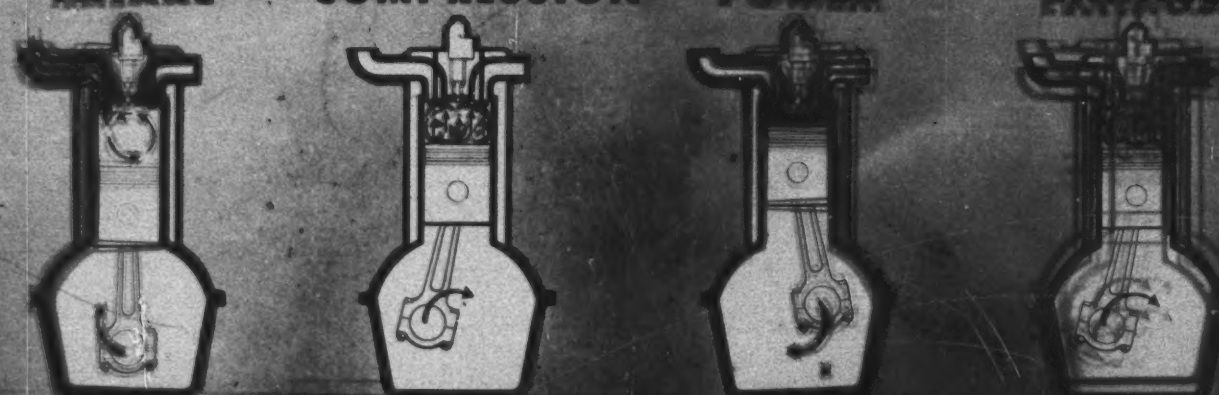
3

Need one 82

FROM 19 ©

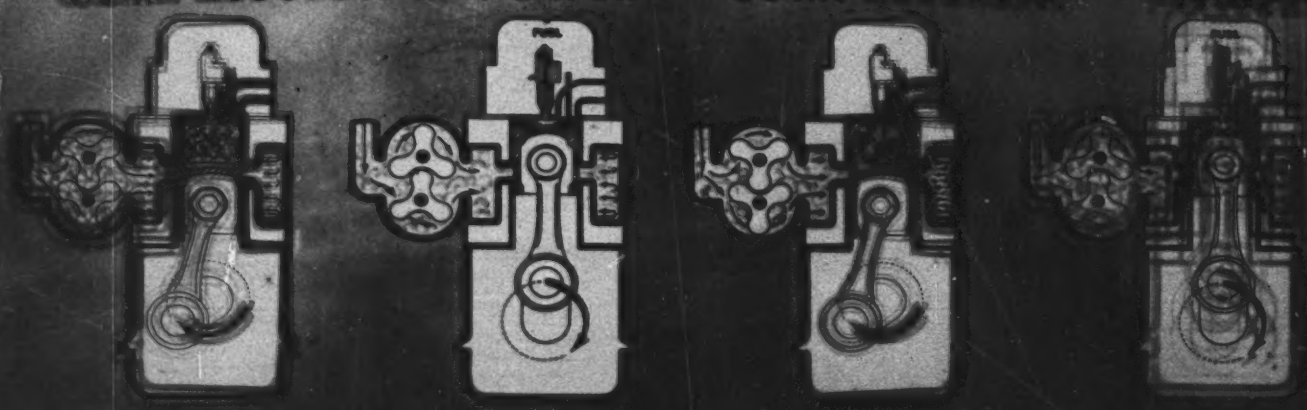
FOUR CYCLE

INTAKE COMPRESSION POWER EXHAUST



TWO CYCLE

COMPRESSION POWER COMPRESSION POWER



HUMAN ENGINEERING INSTITUTE

2341 College

Cleveland

®

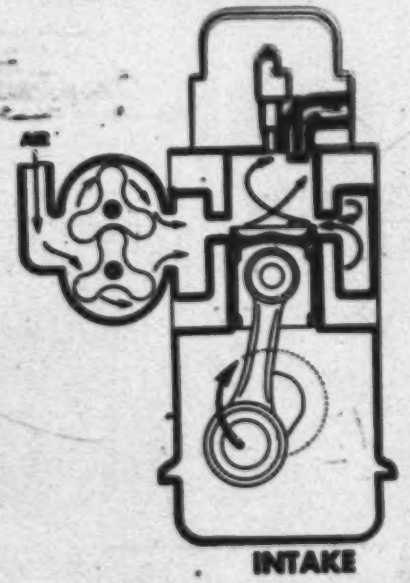
HUMAN
ENGINEERING
INSTITUTE

2341 Carnegie Ave
Cleveland, Ohio 44115

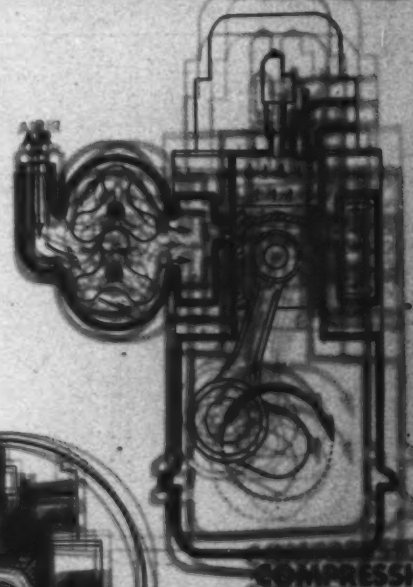
R

HUMAN
ENGINEERING
INSTITUTE

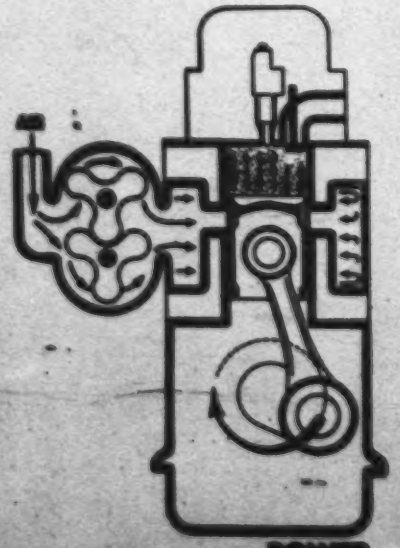
2 STROKE CYCLE DIESEL ENGINE



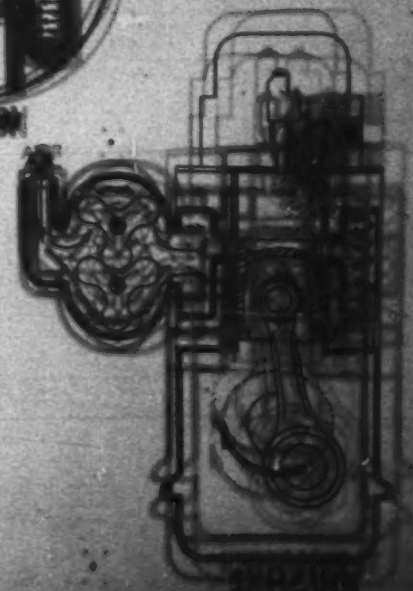
INTAKE



COMPRESSION



POWER

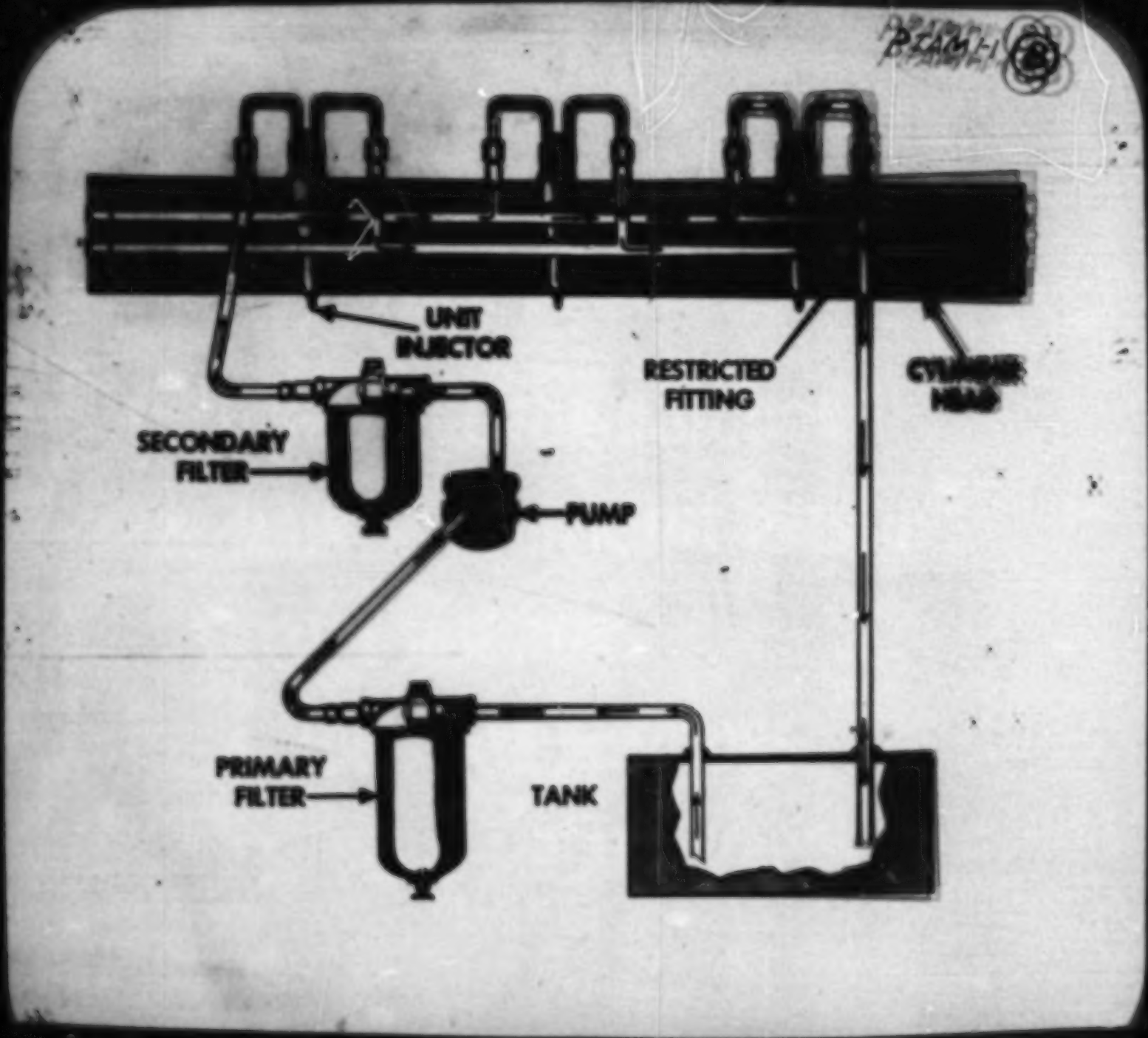


BLOWER FUNCTIONS

1. SCAVENGING
2. COOLING
3. COMBUSTION
4. CRANKCASE VENTILATION
5. AIR BOX DRAINS

FUNCTIONS OF THE FUEL SYSTEM

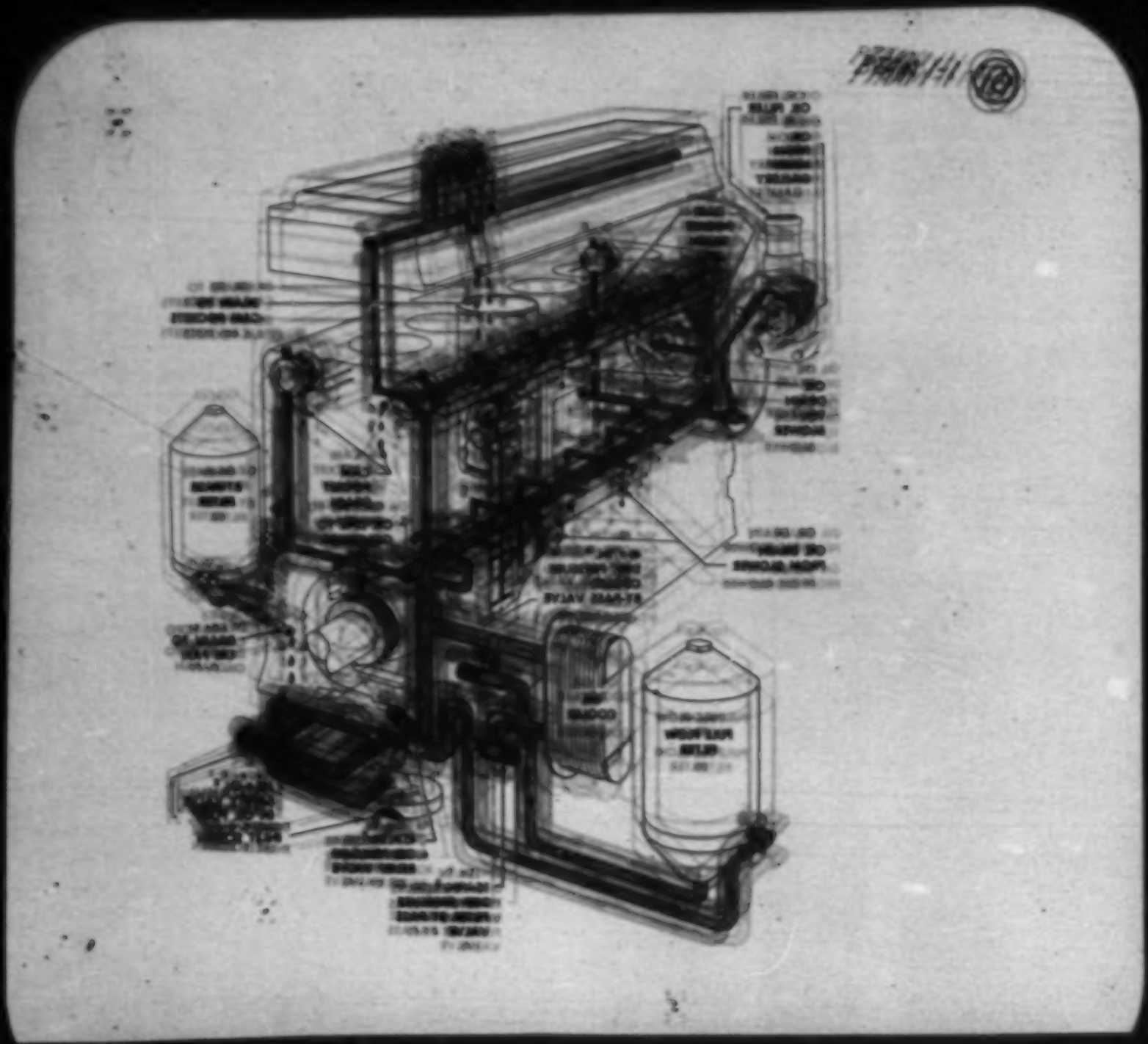
1. SUPPLY FUEL FOR INJECTION
2. MAINTAIN SUFFICIENT PRESSURE
3. COOL INJECTORS
4. LUBRICATE INJECTORS
5. MIXED AIR AND VAPOR


UNIT
INJECTOR
RESTRICTED
FITTING
SECONDARY
FILTER
PUMP
PRIMARY
FILTER
TANK

THE FUNCTIONS OF THE LUBRICATION SYSTEM

1. CIRCULATION
2. DISTRIBUTION
3. FILTRATION
4. TEMPERATURE CONTROL

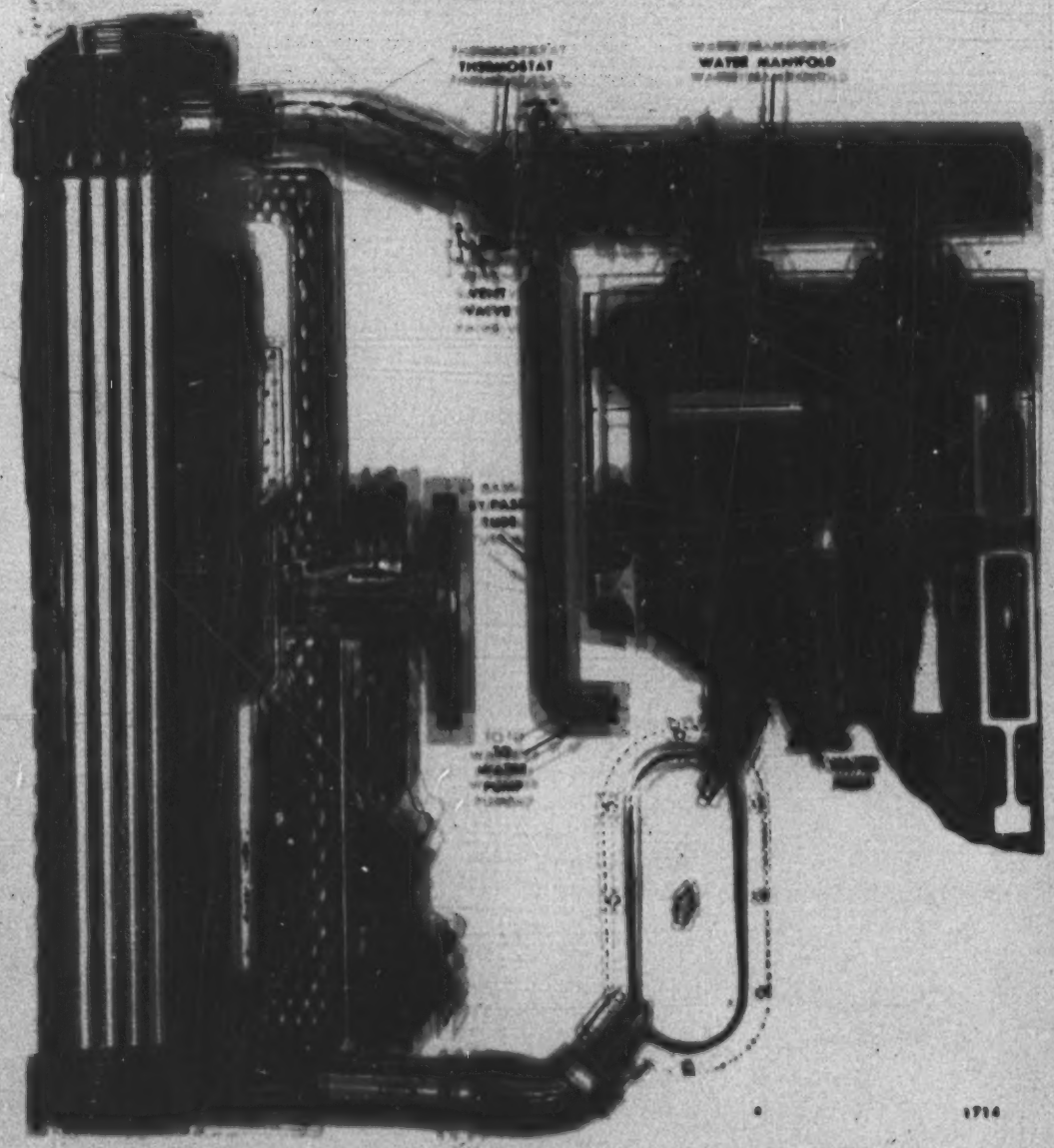
HUMAN
ENGINEERING
INSTITUTE



HUMAN
ENGINEERING
INSTITUTE

2341 Carnegie Ave
Cleveland, Ohio 44115

I-71 Cooling System



HUMAN
ENGINEERING
INSTITUTE

TRAINING OF KEY PRODUCTION AND MAINTENANCE
GUIDANCE • CAREER PLANNING AND COUNSELING

INSTRUCTOR'S GUIDE

Title of Unit: General Introduction To Diesel Engines

Code: PTAM 1-1
9/29/65

OBJECTIVES for this unit:

Know how a diesel engine differs from a gas engine.
Know what a diesel engine consists of.
Know what are considered the advantages of a diesel engine.
Know what a two cycle engine is and how it works.
Know how a two cycle engine differs from a four cycle.
Know what the following features are:

- Cylinder liners
- Overhead valve mechanism
- Air system and Roots Blower
- Four flows of a diesel engine (their components, in general)

TRAINING AIDS:

16mm Film - ABC's of Diesel Engine - General Motors

The following VUE CELLS -
PTAM 1-1 (1) (2 cycle vs 4 cycle)
PTAM 1-1 (2) (4 cycle)
PTAM 1-1 (3) (4 cycle)
PTAM 1-1 (4) (2 cycle)
PTAM 1-1 (5) (air intake and exhaust)
PTAM 1-1 (6) (blower functions)
PTAM 1-1 (7) (functions of fuel system)
PTAM 1-1 (8) (fuel system)
PTAM 1-1 (9) (function of the lube system)
PTAM 1-1 (10) (lubrication system. In-line engine)
PTAM 1-1 (11) (cooling system)

QUESTIONS:

1. What components of the diesel and gas engine are similar?
2. How does a diesel engine differ from a gas engine?
3. What are some advantages of a diesel engine?
4. What are some disadvantages of a diesel engine?
5. What is a two cycle engine?

Questions cont'd.

6. What are the two cycles?
7. What happens in each cycle?
8. What is a four cycle engine?
9. What are the four cycles?
10. What is a cylinder liner? Why is a liner used?
11. What is the overhead valve mechanism?
12. Why does a diesel (two cycle) need a blower?
13. Why doesn't a four cycle need a blower?
14. Do all diesels require intake valves?
15. What are the four-flows of a diesel?